Updates on CEOS/CGMS climate working group and how operational satellite programs can contribute to long term climate records

Jörg Schulz

+ Contributions of many inside and outside of EUMETSAT

PART I

The Joint CEOS/CGMS Working Group on Climate

Jörg Schulz, EUMETSAT

John Dwyer, USGS

Chairs Joint CEOS/CGMS Working Group on Climate

Short History

- CEOS Working Group on Climate endorsed at CEOS Plenary in 2010;
- The joint development of the high-level architecture for climate monitoring from space led to the formation of the Joint CEOS/CGMS WGClimate endorsed by CEOS and CGMS Plenaries in 2013
- Major Task is: Coordinate and encourage collaborative activities between the world's major space agencies in the area of climate monitoring.

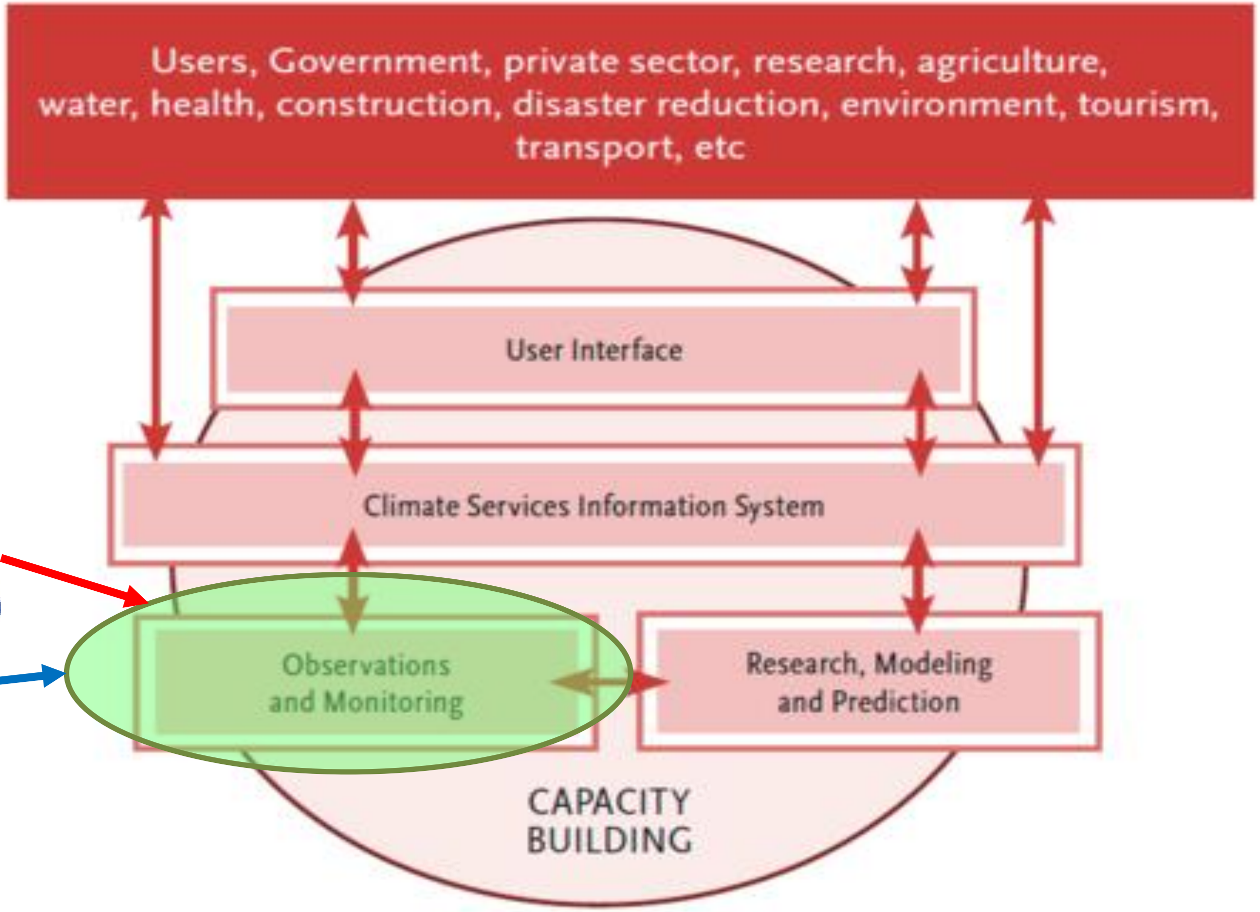
JWGClimate
Chair: Jörg Schulz (EUMETSAT)
Vice Chair: John Dwyer (USGS)

WMO Global Framework for Climate Services (GFCS)

2011

The Vision of GFSC:

"Enable better management of adaptation to climate change through the development and incorporation of science-based climate information and prediction into planning, policy and practice"



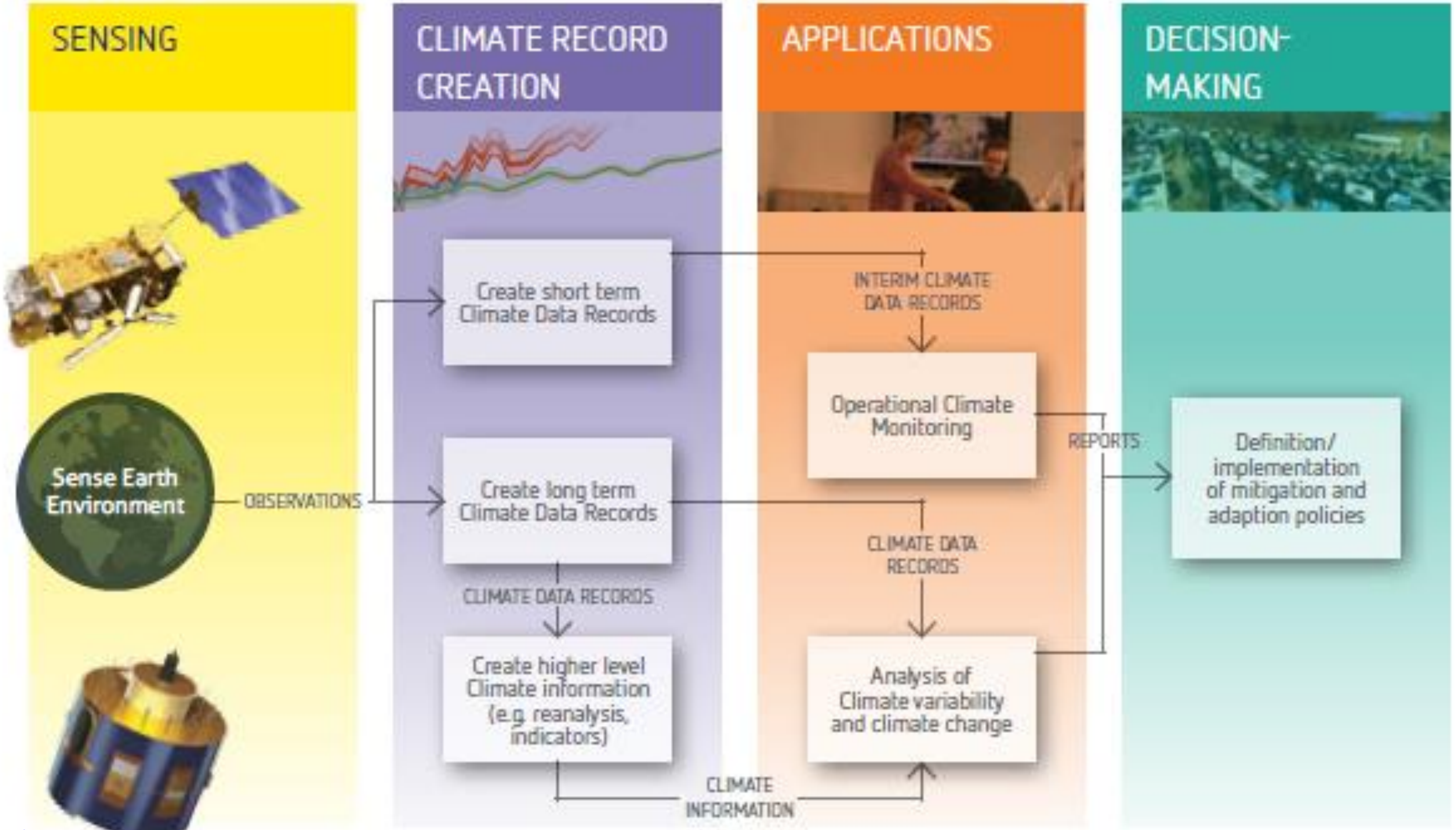
GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

WGClimate
The Joint CEOS/CGMS Working Group on Climate

Space Agency contribution

The Architecture for Climate Monitoring from Space

2013

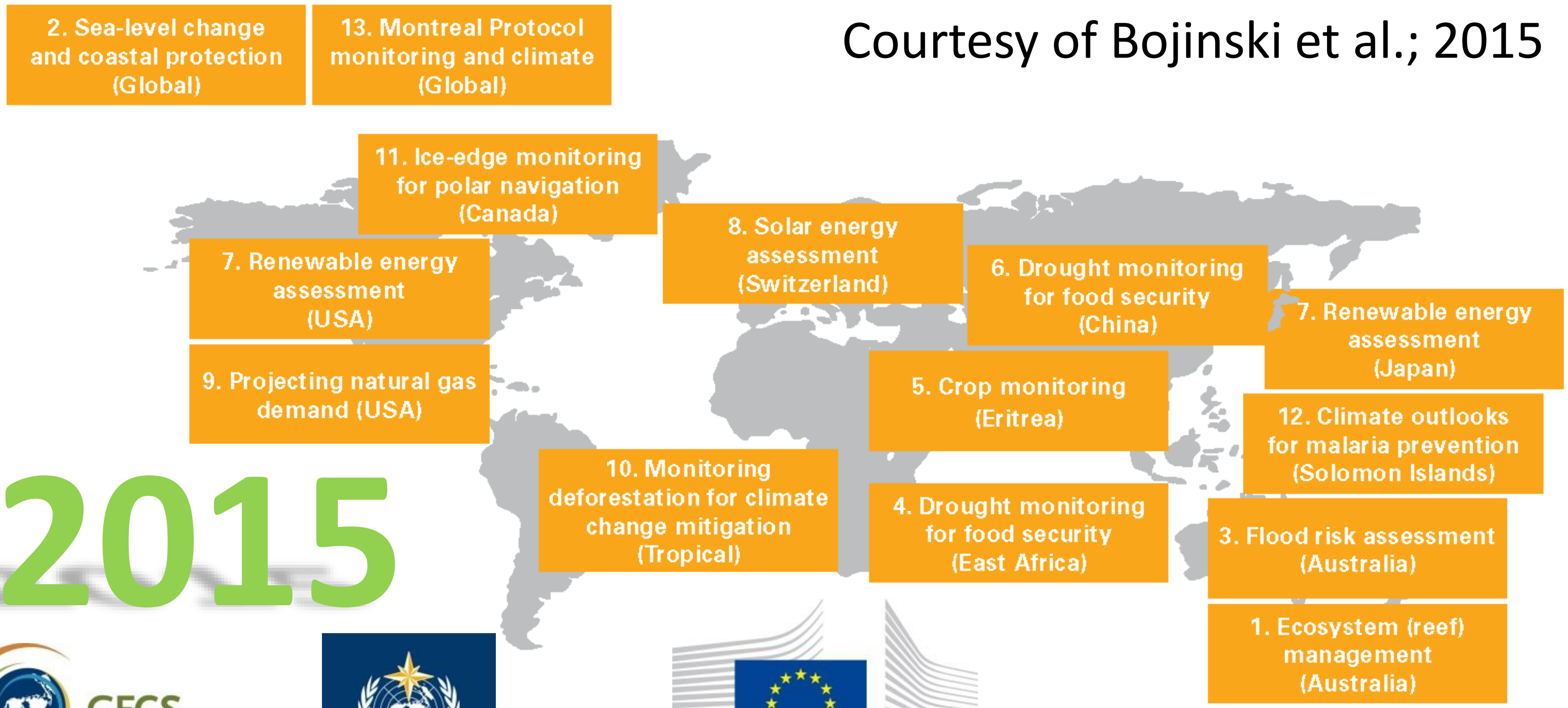


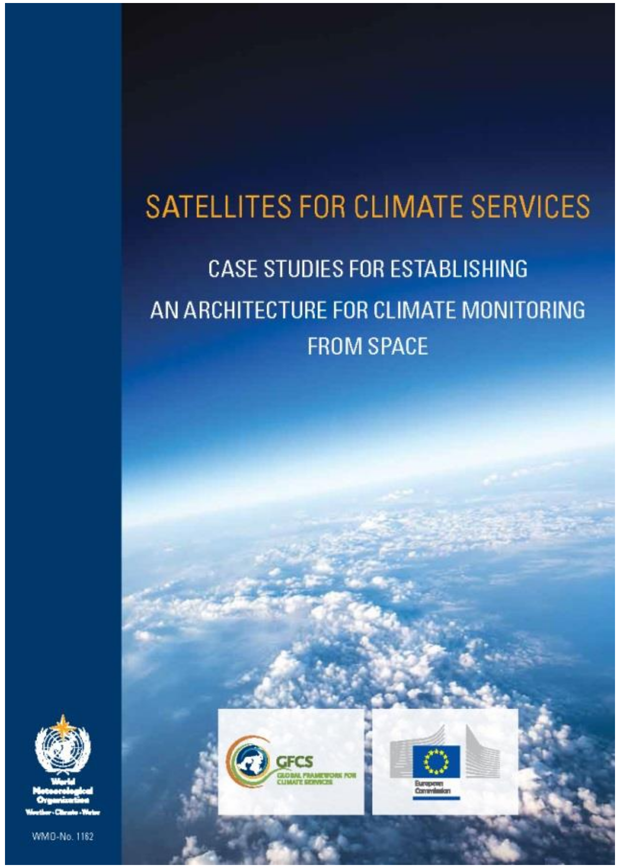
http://ceos.org/document_management/Working_Groups/WGClimate/WGClimate_Strategy-Towards-An-%20Architecture-For-Climate-Monitoring-From-Space_2013.pdf

WGClimate
The Joint CEOS/CGMS Working Group on Climate

Enhancing use of climate data records

Courtesy of Bojinski et al.; 2015





2015

http://library.wmo.int/pmb_ged/wmo_1162_en.pdf

Committee on Earth Observation Satellites

UNFCCC/GCOS – CEOS/CGMS Relations

United Nations
Climate Change
2015

COP-21 Paris Agreement: Adaptation (Article 7(c)):
Strengthening scientific knowledge on climate, including research, **systematic observation of the climate system** and early warning systems, in a manner that informs climate services and supports decision-making.

Reports on Progress @ SBSTA/COP

Needs and Requirements

Coordinated Response

Committee on Earth Observation Satellites

WGClimate
The Joint CEOS/CGMS Working Group on Climate

CGMS

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

GCOS Implementation Plan & The Comprehensive Answer

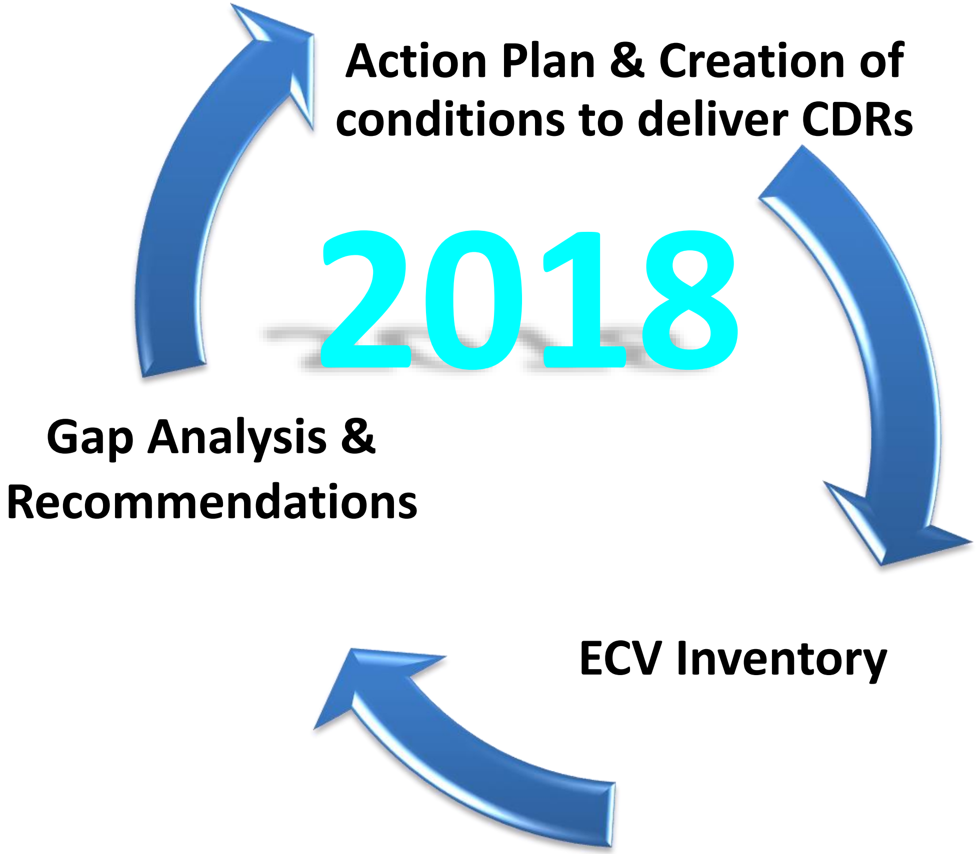
Action G11:	Review of availability of climate data records
Action	Provide a structured, comprehensive and accessible view as to what CDRs are currently available, and what are planned to exist, together with an assessment of the degree of compliance of such records with the GCOS requirements for the ECV products indicated in Annex A

Action G12:	Gap-analysis of climate data records
Action	Establish a gap analysis process and associated actions, to: (a) address gaps/deficiencies in the current available set of CDRs; and (b) ensure continuity of records, and address gaps through the appropriate planning of future satellite missions for the ECV products indicated in Annex A

- Answer contains status and plans for all actions in GCOS IP relevant for space agencies.
- Allows reporting of progress on GCOS needs to UNFCCC.

Resource for Coordinated Response

http://climatemonitoring.info



- ECV Inventory fully describes current and planned implementation arrangements (ECV-by-ECV) within the Architecture;
- Almost 1000 data records including direct access in many cases (NOAA has big population with long records);
- Content fully verified;
- Updated annually with approval from CEOS and CGMS;
- Derived Recommendations and Coordinated Actions inform space agency planning, improves availability and interoperability of climate data;
- Feeds material for all future responses to the GCOS IP.

The ECV Inventory


Climate Monitoring from Space

WGClimate
The joint CEOS/CGMS
Working Group on Climate

RSS

Climate Monitoring | Observation Needs | Architecture | Coordination | ECV Inventory | Case studies | Contact

2018

Climate Monitoring from Space

Satellite data play a pivotal role in observing variability and change in the Earth system. Significant progress has been made in observing the Earth globally with higher temporal and spatial resolutions, which before the advent of satellites was all but impossible. With satellite observations of the Earth, we have been able to construct global views of many variables across the atmospheric, oceanic and terrestrial domains, including ozone, cloud cover, precipitation, aerosol optical depth, sea surface topography, fluctuation in polar ice mass, and changes to the land surface. Indeed, with some satellite observations now spanning more than 40 years, this type of information for climate monitoring purposes is now invaluable.

In situ observations play an important role as well. Existing *in situ* networks provide observations of parameters that are difficult and/or impossible to measure from space. They also serve as validation for satellite observations, can be used in joint analyses with satellite data, and in specific cases (e.g. optical measurements of land and ocean surfaces) provide a means of vicariously calibrating the space-based observations. Therefore, the combination of satellite and ground-based observations is essential. Whilst recognising the importance of integrated observing systems, the initial focus of this website lies with the space-based component used for climate monitoring.

- Public access to Inventory via climatemonitoring.info
- Users can:
  - Download the ECV Inventory content for own analysis;
  - Find direct access points to all CDRs in the Inventory;
  - Get access to WGClimate gap analysis results and planned actions;
  - Can access case studies analysing the use of CDRs for applications.

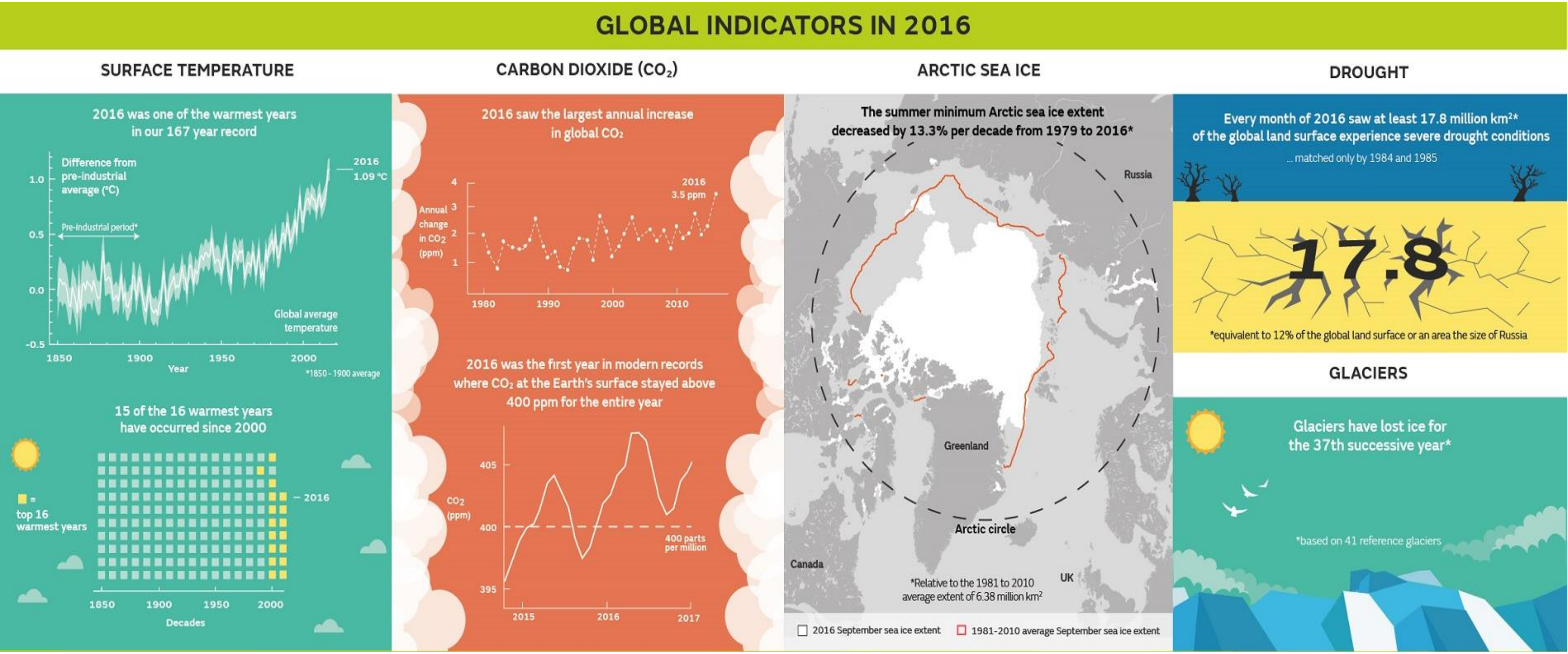
Summary Part I

- Joint CEOS/CGMS WGClimate is the focal of point of space agencies to address GCOS requirements and is the single coordinated voice towards UNFCCC;
- The ECV Inventory provides a resource for the whole community that wants to use and create climate data records – Use it to find data for applications, examples provided!
- WGClimate has developed the tools for effective analysis of space agency data holdings and plans, to optimise utilisation of existing measurements and planning of new measurements for climate monitoring;
- The implementation of the architecture for space-based climate monitoring requires an ongoing analysis of every pillar of the architecture and their interactions.

PART II

How operational satellite programs can contribute to long term climate records?

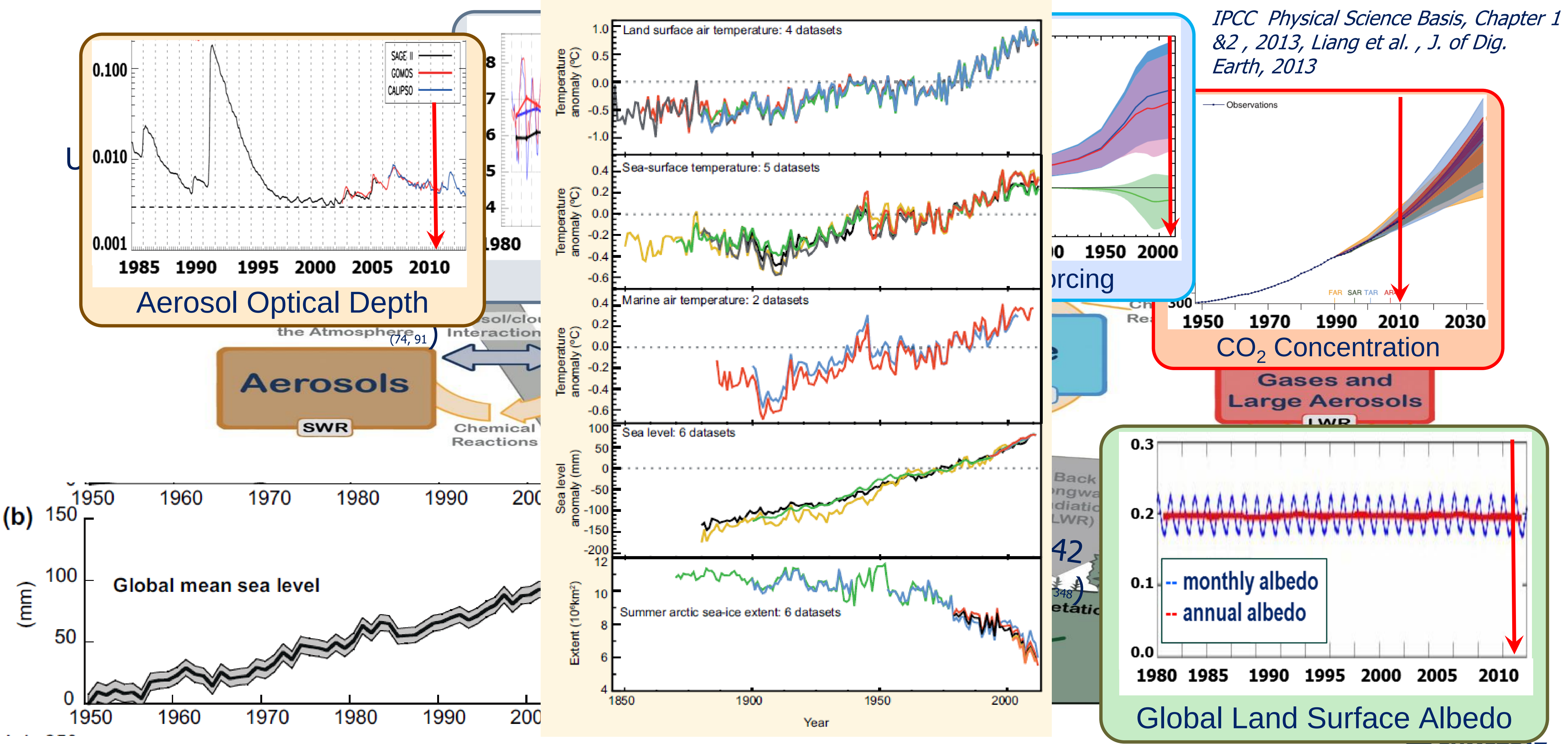
Climate Change - Facts



UK-MetOffice, 2017

Climate System: What needs to be observed?

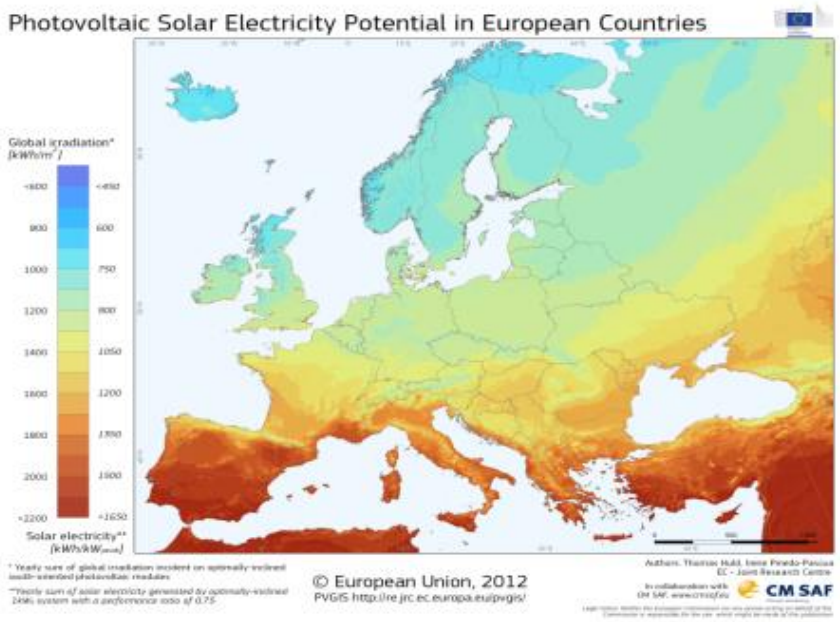
IPCC Physical Science Basis, Chapter 1 &2 , 2013, Liang et al. , J. of Dig. Earth, 2013



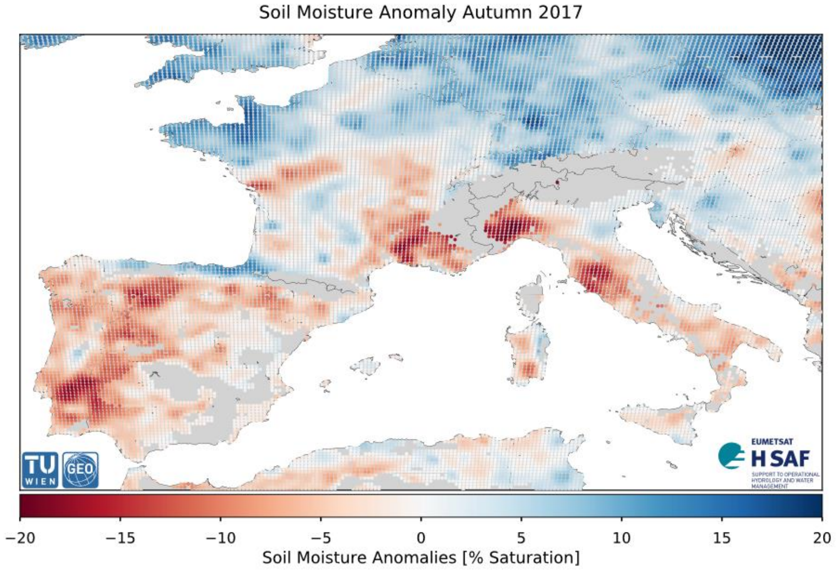
EUMETSAT Contribution to Climate Monitoring

- Long term, multi-satellite programmes, with service continuity
- Continuous improvement, expansion of portfolio of observations
- Unique patrimonial archive: decades of observations
- Data rescue (historic satellite observations)
- Recalibration and production of climate records
  - Physical parameters directly observed by satellites: level 1 (mostly done at EUM HQ)
  - Geophysical parameters: ECVs (ocean, atmosphere, land) (mostly done by EUM SAF)
  - Estimation of uncertainties
- Data access
- Cooperation with users: validation, research, applications
- Training, support to climate-related capacity building initiatives

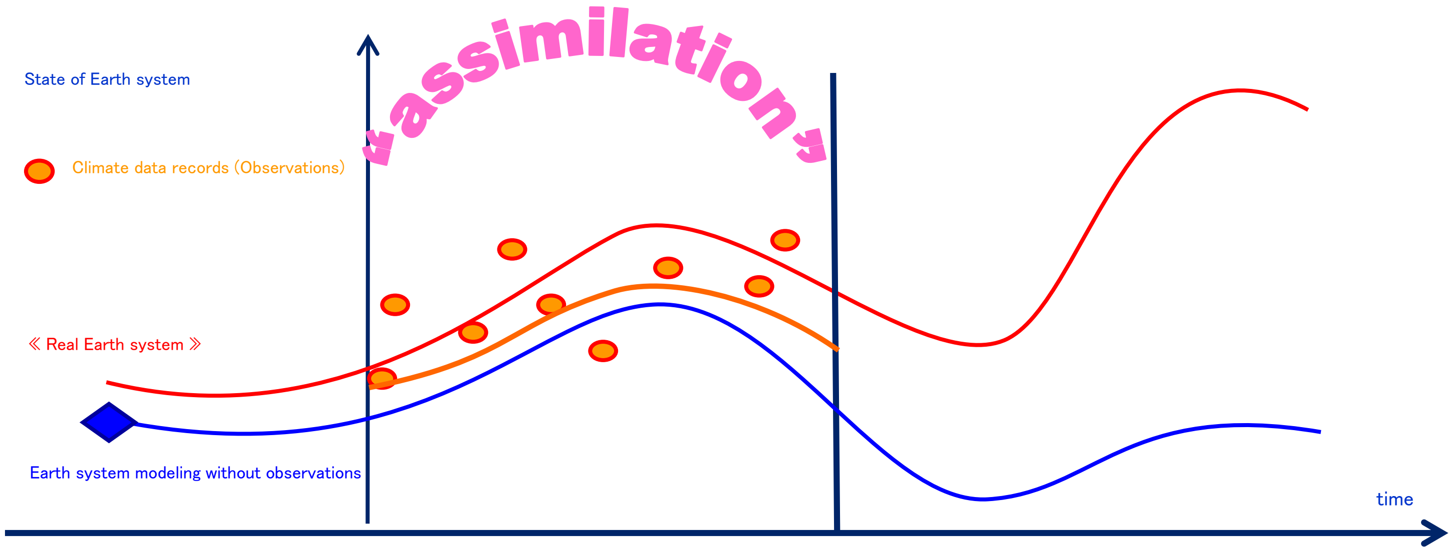
Use of Data Records



DIRECT USE



REANALYSIS USING EARTH SYSTEM MODELS



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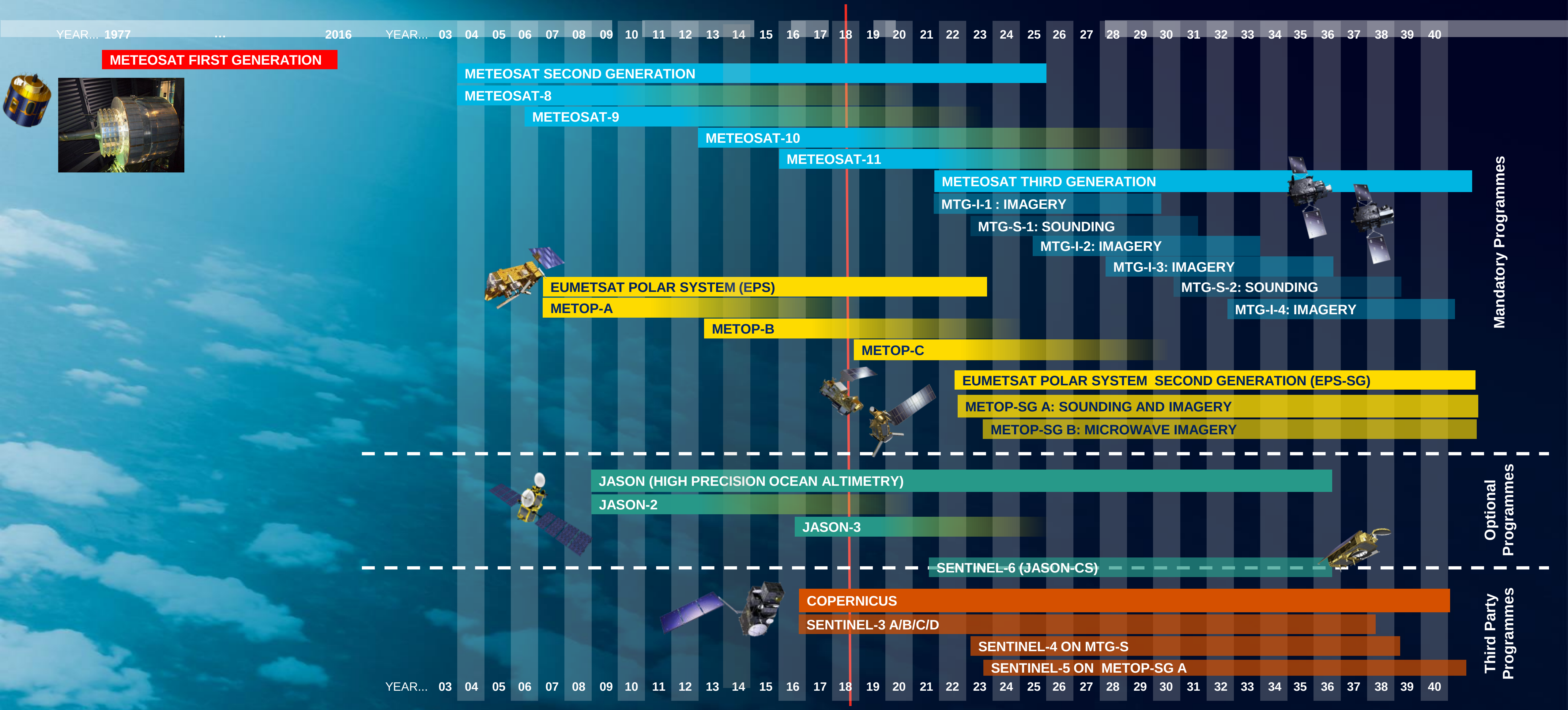
Long term commitment: multi-satellite programmes



EUMETSAT

Meteosat: Spectral, Spatial and Temporal Sampling

	Meteosat 1st Generation			Meteosat 2nd Generation			Meteosat 3rd Generation		
'Core' channels	Central wavelength (μm)	Width (FWHM) (μm)	Spatial Sampling (km)	Central wavelength (μm)	Width (FWHM) (μm)	Spatial Sampling (km)	Central wavelength (μm)	Width (FWHM) (μm)	Spatial Sampling (km)
FC-VIS 0.4							0.444	0.06	1.0
FC-VIS 0.5							0.510	0.05	1.0
FC-VIS 0.6	0.7	0.35	2.5	0.635	0.08	3.0	0.645	0.08	0.5
FC-VIS 0.8				0.81	0.07	3.0	0.86	0.07	1.0
FC-NIR 0.9							0.96	0.06	1.0
FC-NIR 1.3							1.375	0.03	1.0
FC-NIR 1.6				1.64	0.14	3.0	1.61	0.06	1.0
FC-NIR 2.2							2.26	0.05	0.5
FC-IR 3.8 *				3.9	0.44	3.0	3.8	0.40	1.0
FC-IR 6.2	6.1	1.3	5.0	6.2	1.0	3.0	6.2	1.00	2.0
FC-IR 7.3				7.35	0.5	3.0	7.35	0.50	2.0
FC-IR 8.7 *				8.7	0.4	3.0	8.7	0.40	2.0
FC-IR 9.7				9.66	0.3	3.0	9.66	0.30	2.0
FC-IR 10.8	11.5	1.9	5.0	10.8	1.0	3.0	10.5	0.7	1.0
FC-IR 12.0				12.0	1.0	3.0	12.3	0.5	2.0
FC-IR 13.3				13.4	1.0	3.0	13.3	0.60	2.0
Repeat Cycle :	30 min			15 min			10 min		

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EPS Second Generation – Instruments' Heritage

Metop-SG A Optical Imagery and Sounding	Instrument	Predecessor on Metop	Predecessor
Infrared Atmospheric Sounding (IASI)	IASI-NG	IASI	AIRS, HIRS
Microwave Sounding (MWS)	MWS	AMSU-A, MHS	MSU, AMSU-B, ATMS
Visible-infrared Imaging (VII)	METimage	AVHRR	AVHRR&VHRR
Radio Occultation (RO)	RO	GRAS	CHAMP/COSMIC
UV/VIS/NIR/SWIR Sounding (UVNS)	Sentinel-5	GOME-2	GOME
Multi-viewing, -channel, -polarisation Imaging (3MI)	3MI	-/-	POLDER

Metop-SG B Microwave Laboratory	Instrument	Predecessor on Metop	Predecessor
Scatterometer (SCA)	SCA	ASCAT	ERS-1 Scat
Radio Occultation (RO)	RO	GRAS	CHAMP/COSMIC
Microwave Imaging for Precipitation (MWI)	MWI	-/-	SSMIS, SSM/I, SMMR
Ice Cloud Imager (ICI)	ICI	-/-	-/-
Advanced Data Collection System (ADCS)	Argos-4	A-DCS	?

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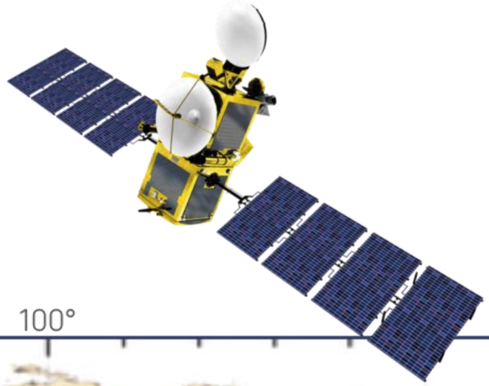
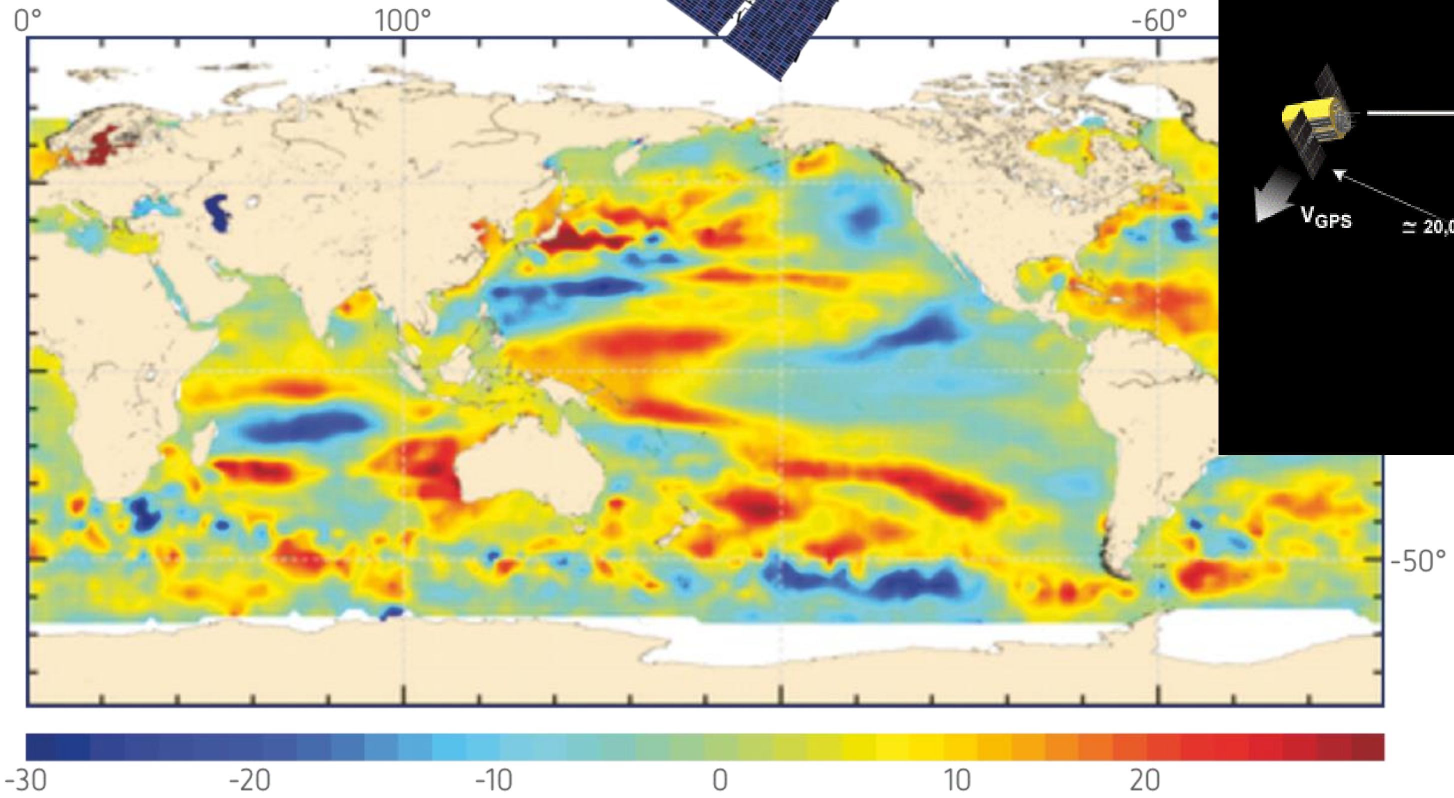
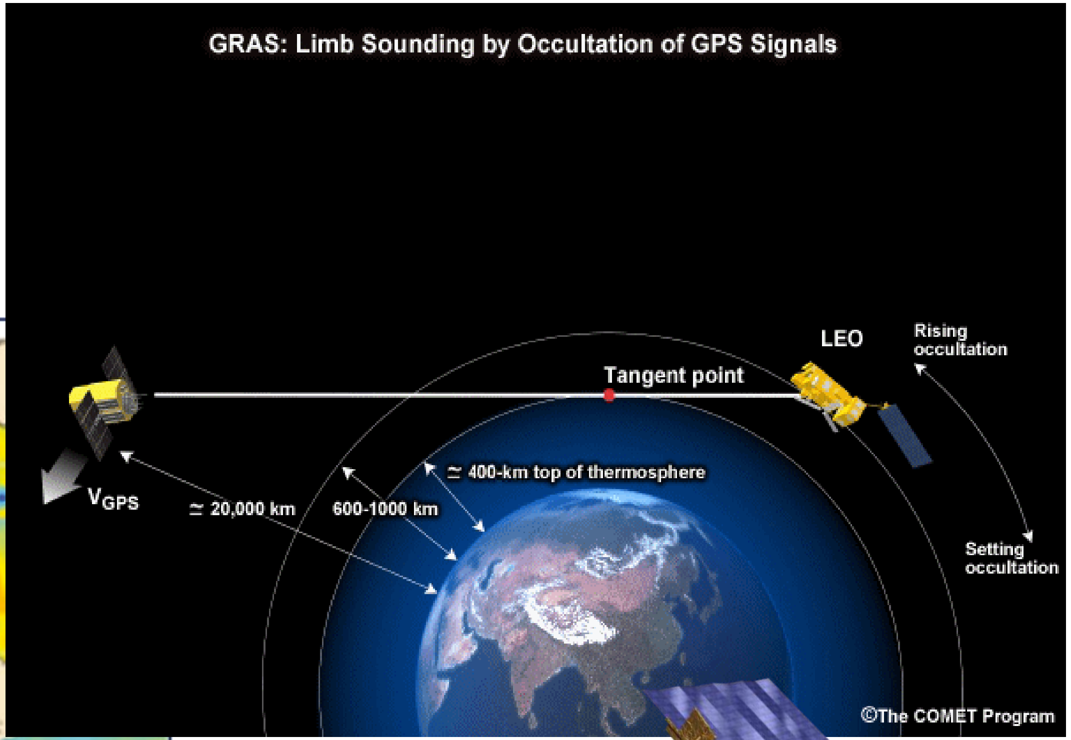
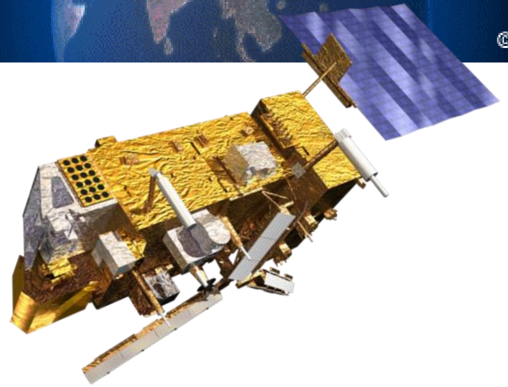
Some missions are optimised for climate monitoring …



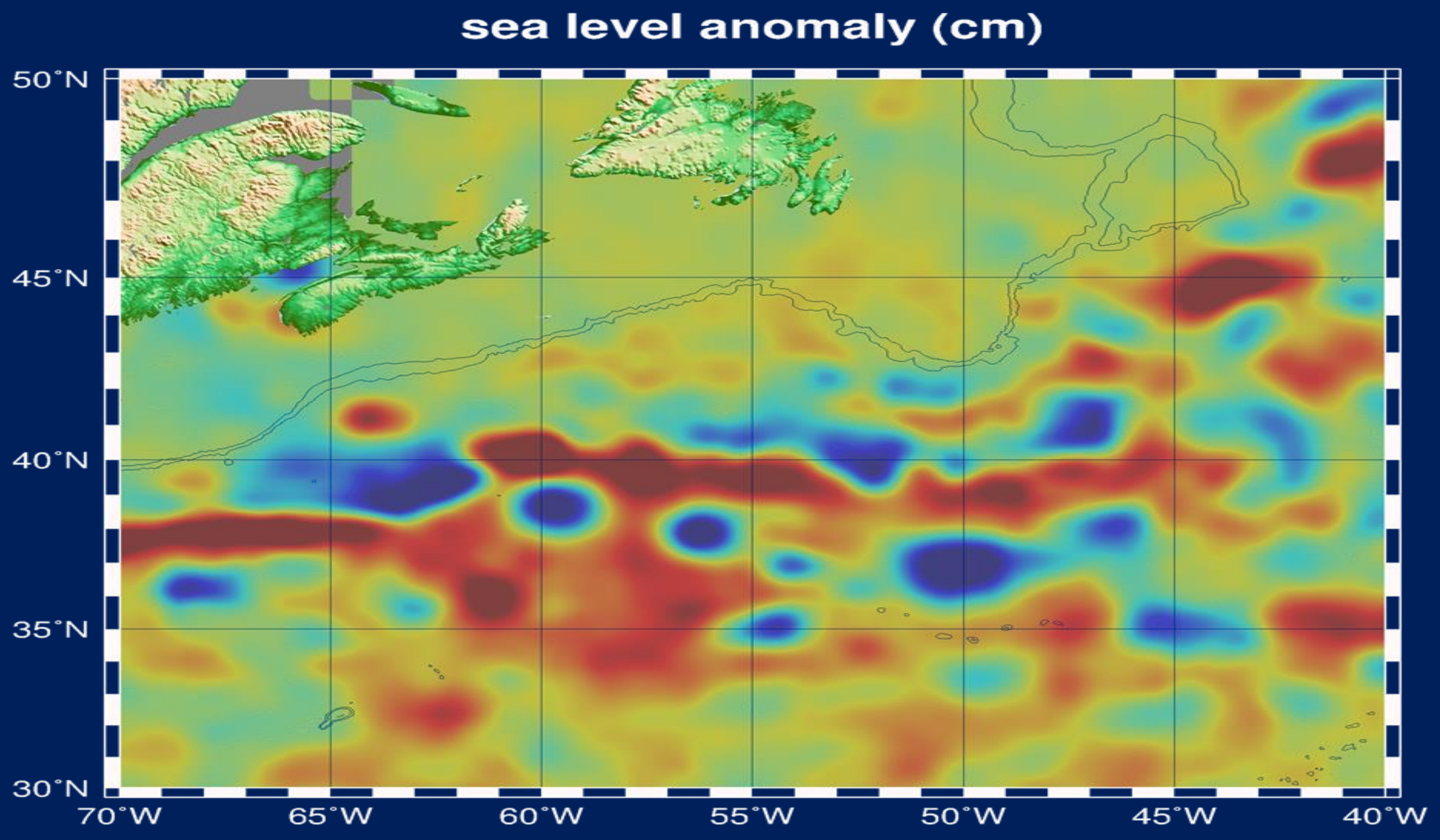


Trends (mm/year I.B. : applied / wet tropo. :RADIOMETER-derived, seasonal signal removed)





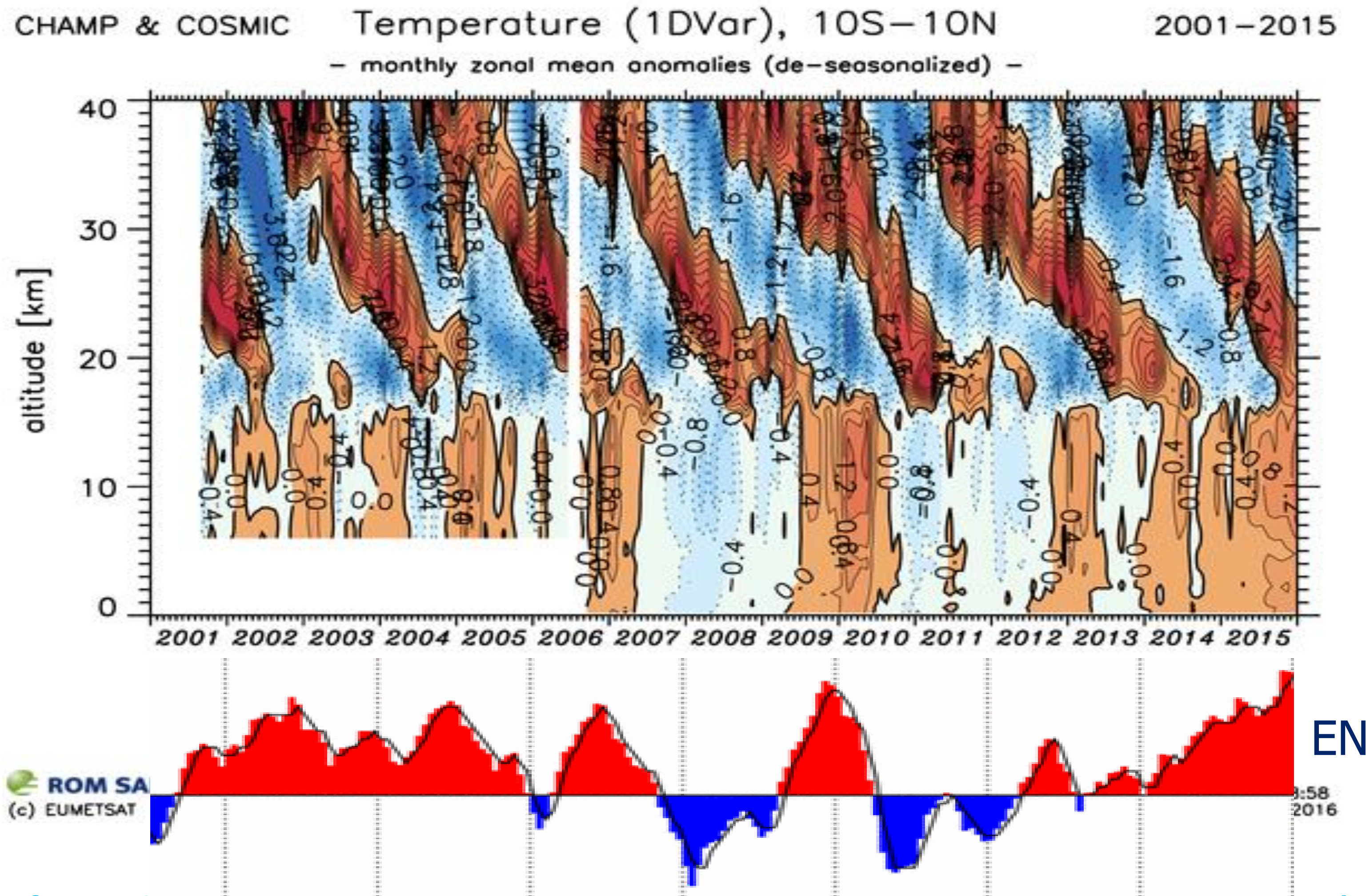
Sea Surface Topography: six missions are operational and interoperable by using the same QA tools



R. Scharroo, EUMETSAT

Radio-Occultation: Data Record Example

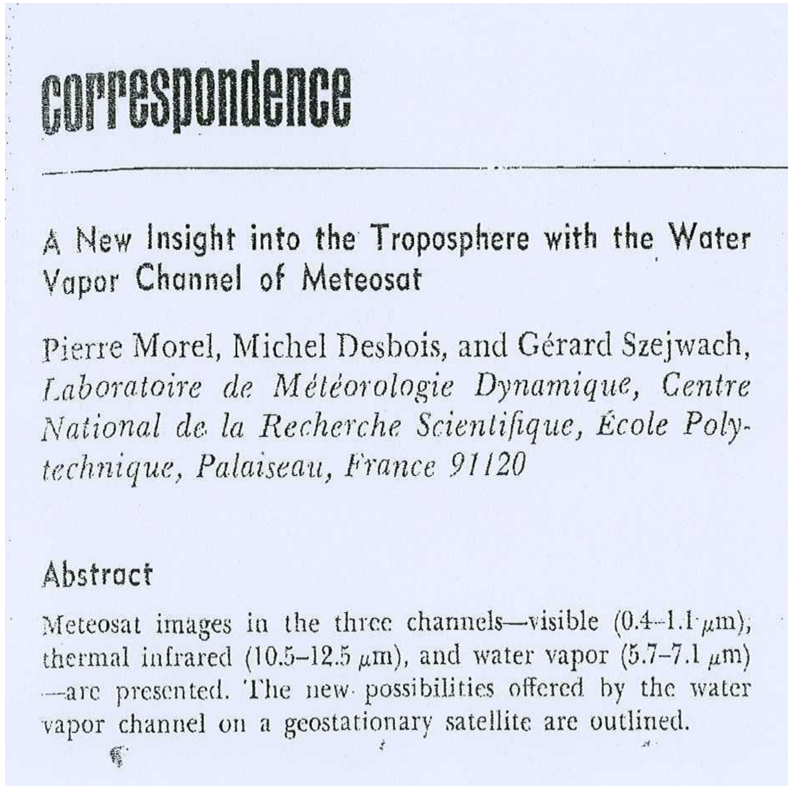
Champ and Cosmic data record monthly mean time series covering the period from September 2001 to June 2015.



ENSO Index

… others are not: Data Rescue and Preservation Challenge – Meteosat-1 -

WV channel, Meteosat 1


correspondence

A New Insight into the Troposphere with the Water Vapor Channel of Meteosat

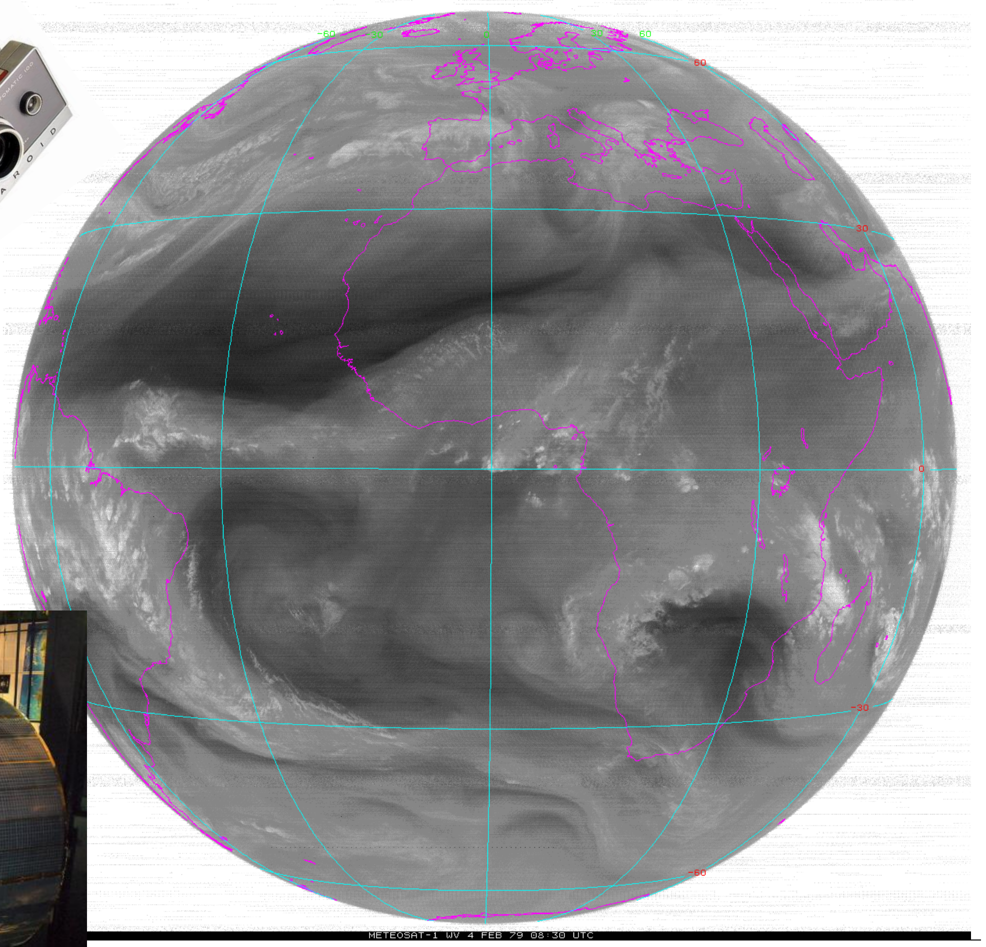
Pierre Morel, Michel Desbois, and Gérard Szejwach, *Laboratoire de Météorologie Dynamique, Centre National de la Recherche Scientifique, École Polytechnique, Palaiseau, France 91120*

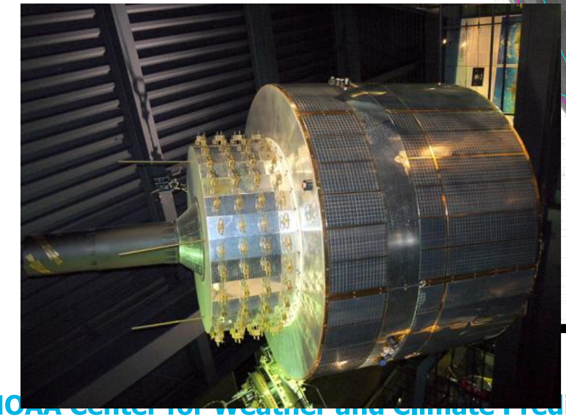
Abstract

Meteosat images in the three channels—visible (0.4–1.1 μm), thermal infrared (10.5–12.5 μm), and water vapor (5.7–7.1 μm) —are presented. The new possibilities offered by the water vapor channel on a geostationary satellite are outlined.

Bulletin of the AMS, 1978

4th February 1979, 15 images (Every hour from 08:30 UTC until 23:30 UTC *(missing images at 18:30 UTC)*





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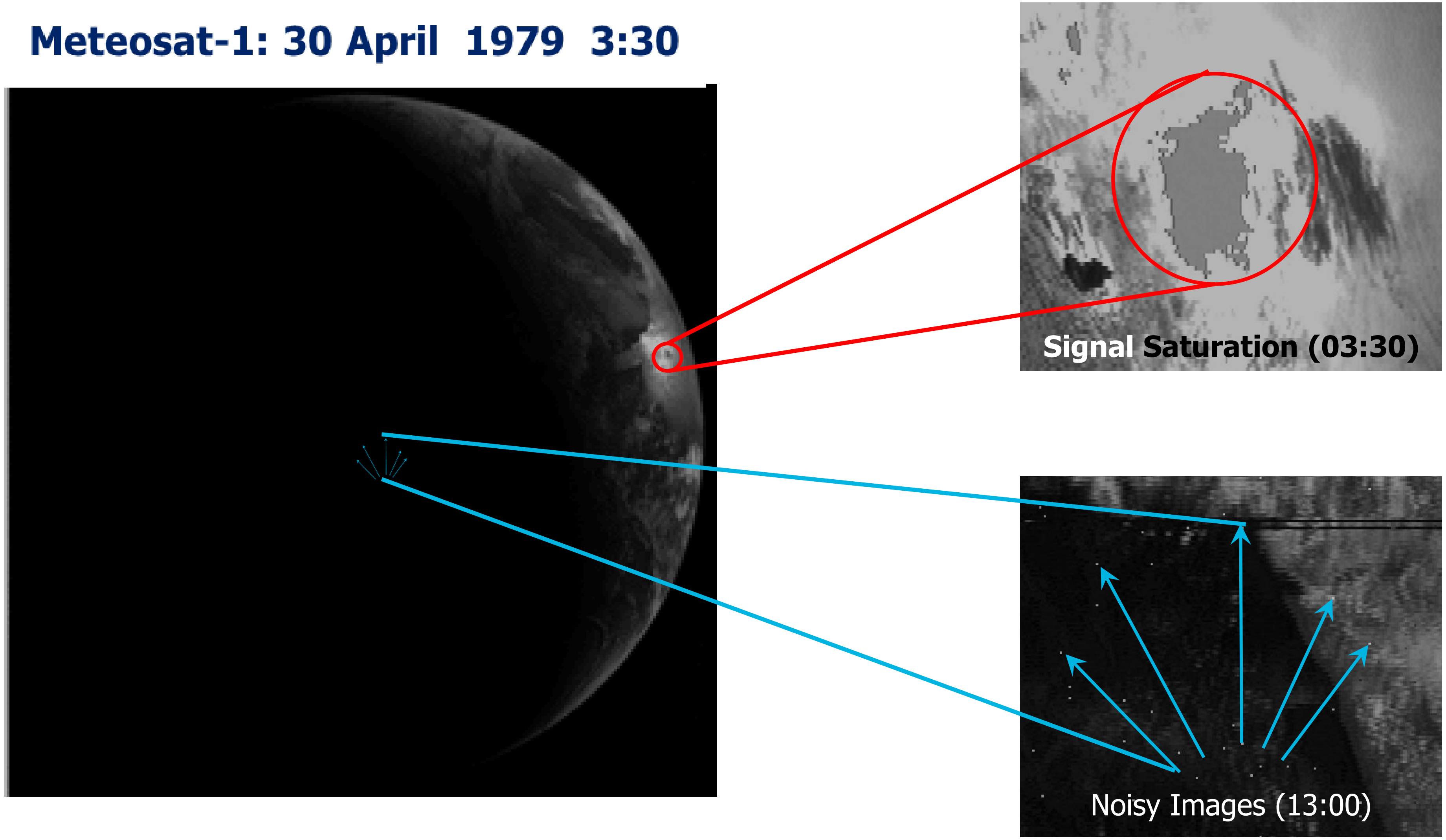
Every image counts
- Analysis of Meteosat-1 data -



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Uncertainties are important

Decision making requires appreciation of uncertainties

- Research is needed to *narrow down* uncertainties
- Science and reference data are needed to *document and trace uncertainties*

Traceability of uncertainties in observations

- Metrology
- Cross-calibration/validation against reference observations
- Evaluation of limitations of processing algorithms

Mature Climate Records Include information on uncertainties

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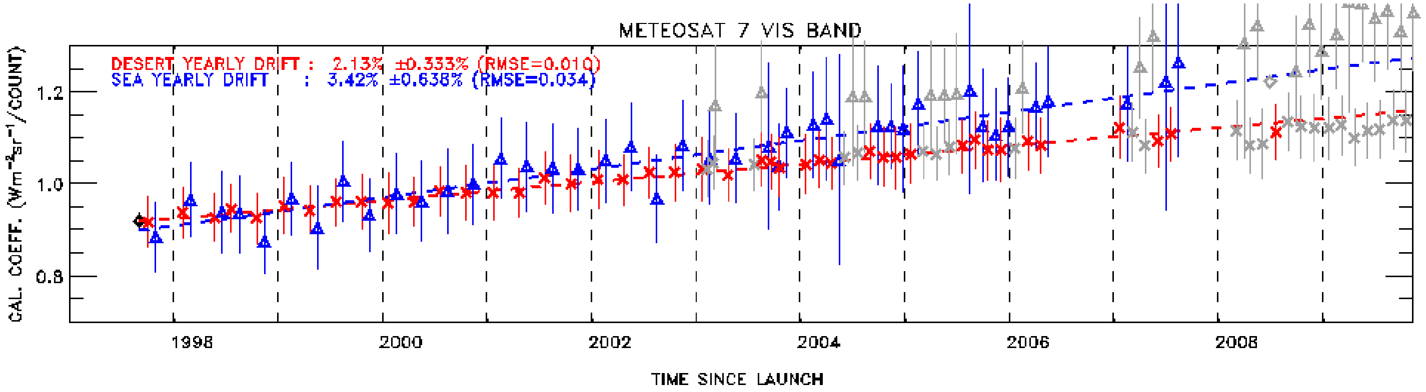
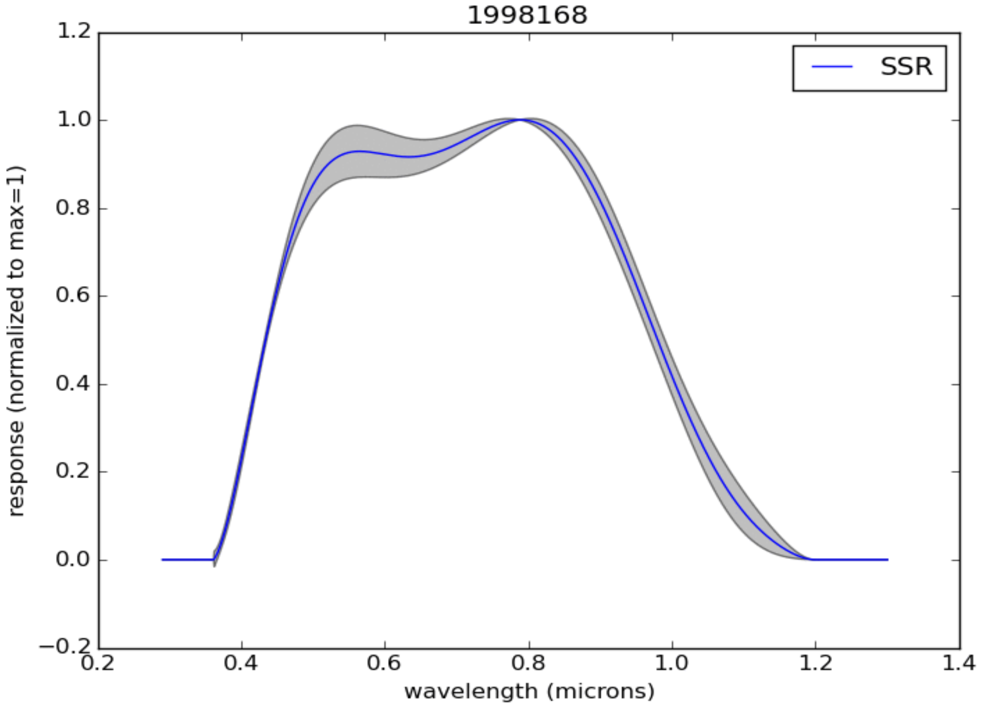
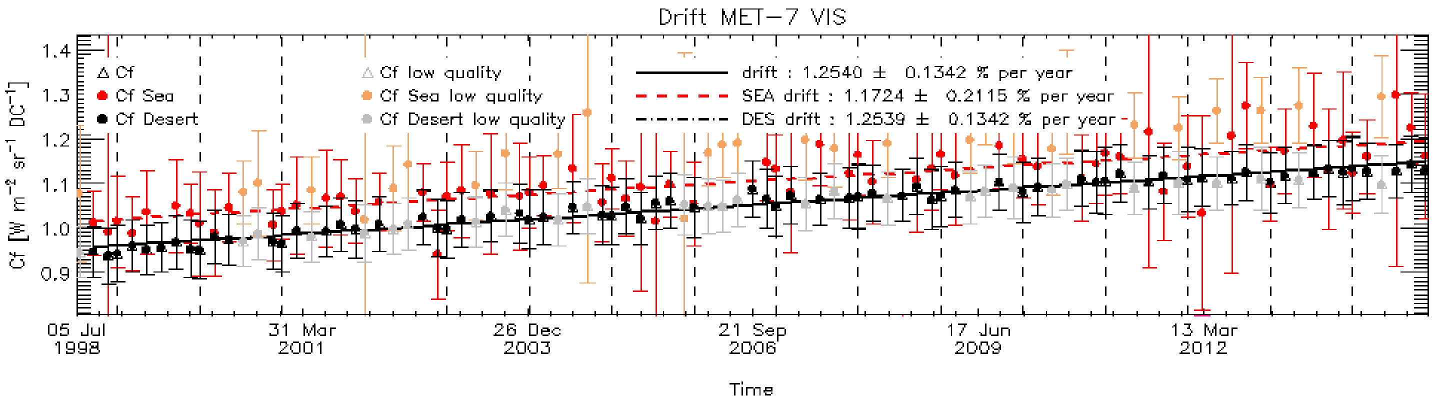
Example: Recalibration of Meteosat Visible Imagery





Reconstruction of temporal variation of spectral response function due to detector ageing improves VIS calibration.



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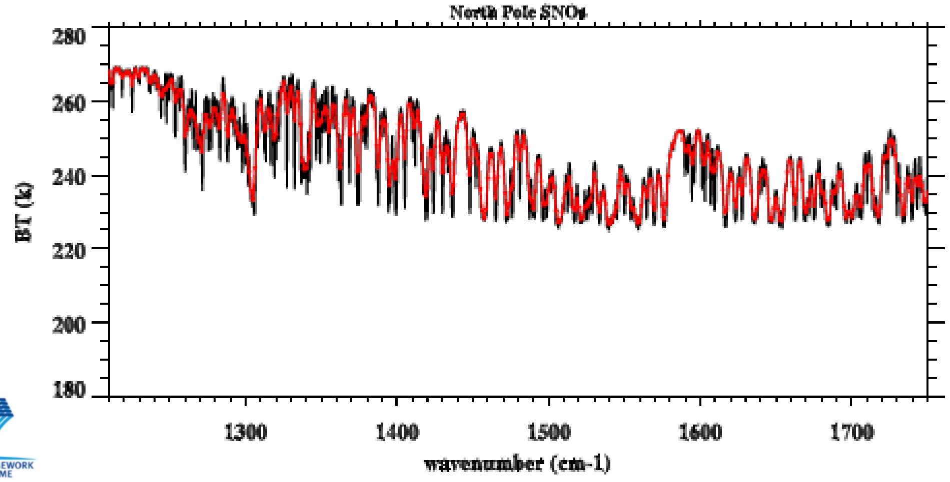
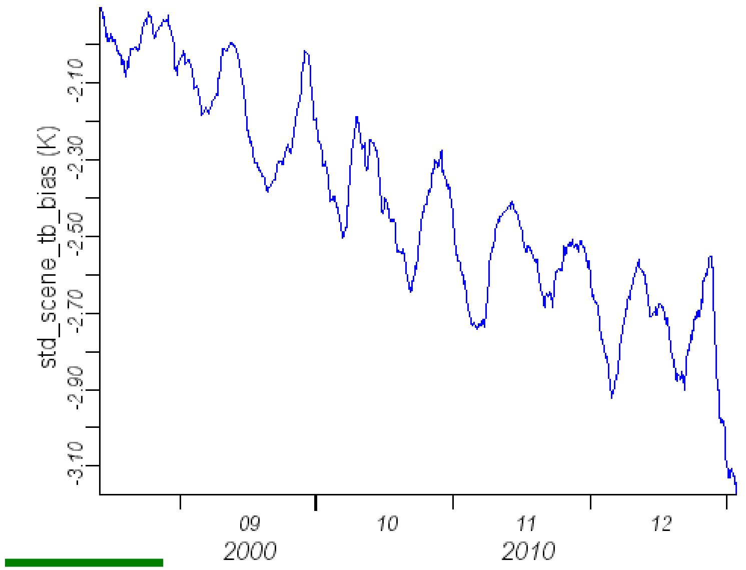
Cross-calibration: IASI as an infrared calibrator

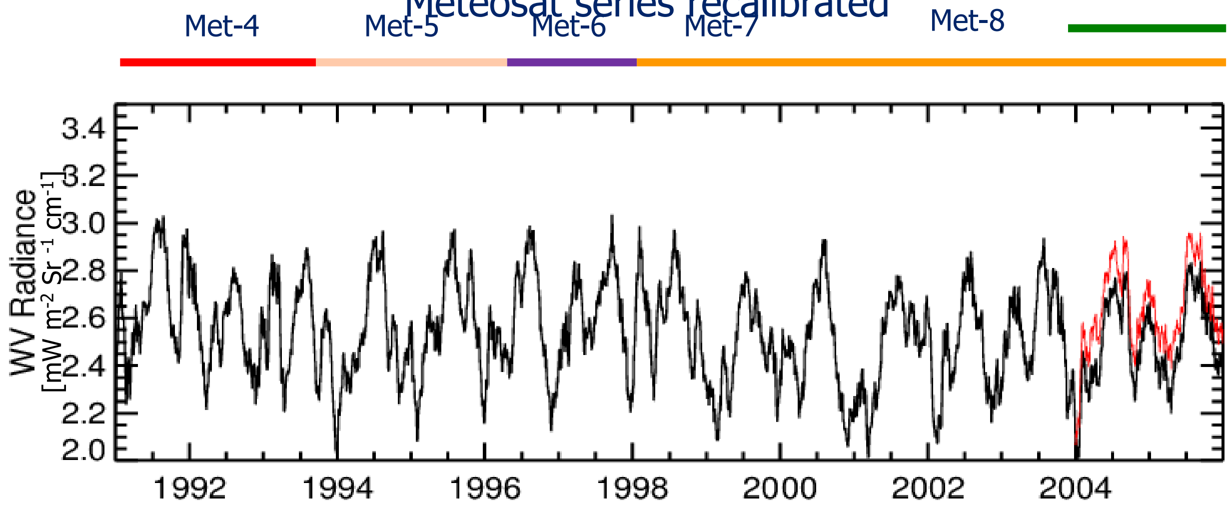
Reference IR Instrument: IASI on Metop



Meteosat first generation against IASI



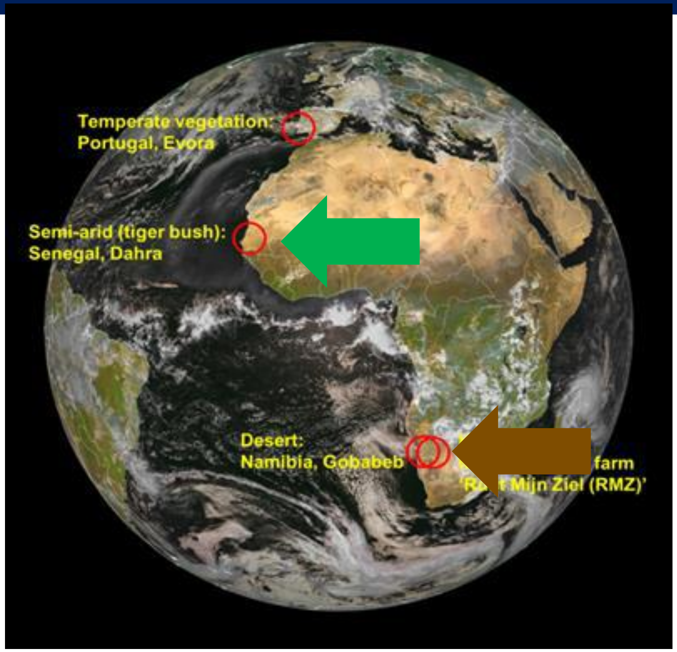
Meteosat series recalibrated



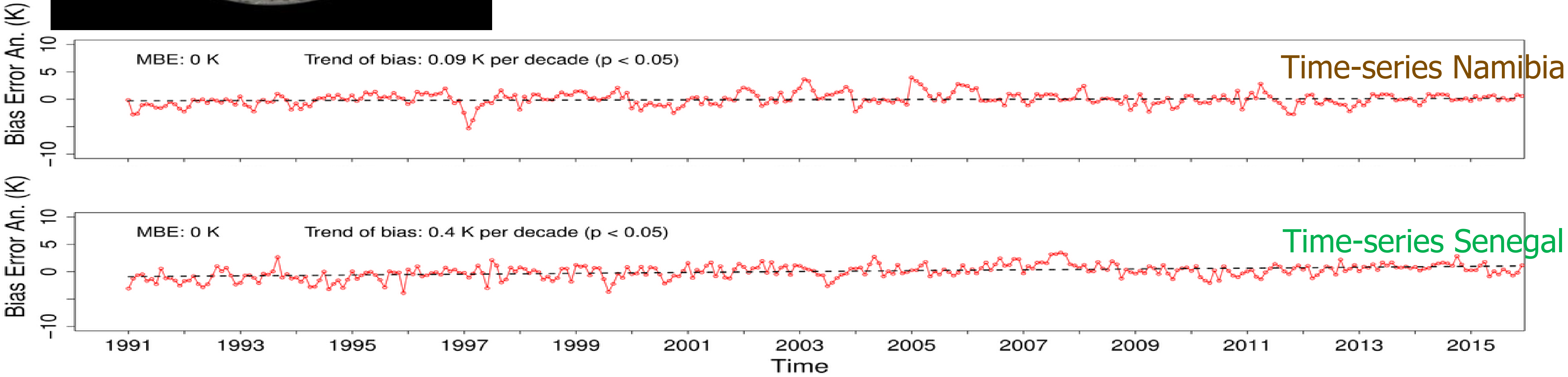
Meteosat First Generation

Meteosat Second Generation

Validation of re-calibrated radiance against Land Surface Temperature measurements



- **CM SAF** validate re-calibrated MVIRI infra-red radiances against Land Surface Temperature (LST) measurements from stations in Namibia and Senegal;
- Trend of mean deviations at 95% significance are:
  -> 0.09 K/decade (Namibia)
  -> 0.40 K/decade (Senegal)
  (Note: global GCOS criteria is 1K/decade).



Courtesy: Anke Duguay-Tetzlaff, Meteo-Swiss

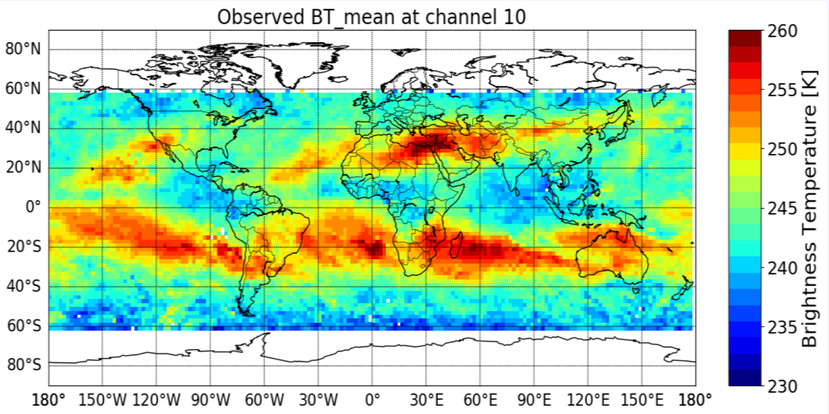
EUMETSAT CDR Availability Status 31/05/2018 (no SAFs)

Data Record	Period	Satellites	Status	Comment
FCDR GOME-2 L1b R1	2007 – 2011	Metop-A	Archived and accessible from Data Centre	
FCDR ASCAT L1b R2	2007 – 2014	Metop-A	Archived and accessible from Data Centre	
FCDR GRAS L1b R1 (geometric optics)	2007 – 2014	Metop-A	Produced, validated, available on request	The data will not be archived due an error in the height referencing of bending angle profiles
FCDR GRAS L1b R1 (wave optics)	2006 – 2016	Metop-A	Produced, validated, available on request.	Archival expected 2018
FCDR GRAS L1b R2 (wave optics)	2006 - 2016	Metop-A/B	Produced, available on request to support validation	2017 will be added to the data record in 2018
FCDR COSMIC L1b R1 (wave optics)	2006 - 2016	COSMIC 1-6	Produced and under validation	Consolidation expected in 2020.
FCDR CHAMP L1b R1 (wave optics)	2001 – 2008	CHAMP	Produced and under validation	Consolidation expected in 2020.
FCDR SSM/T2 R1	1992 – 2008	DMSP F11, F12, F14, ,F15	Produced, validated, available on request	Archival expected 2018
FCDR AMSU-B R1	1999 – 2010	NOAA-15 – NOAA-17	Produced, validated, available on request.	Archival expected 2018
FCDR MHS R1	2005 – 2015	NOAA-18 and 19, Metop A/B	Produced, validated, available on request.	Archival expected 2018
FCDR IASI R1	2006 - 2012	Metop A	Produced, available on request to support validation	Finalised by March 2018. Archival expected 2019.
FCDR Meteosat IR	1982 – 2015	Meteosat 2-9	Produced, validated, available on request	Archival expected 2018
TCDR polar AVHRR AMV R1	2007 – 2012	Metop-A	Archived and accessible from Data Centre	
TCDR polar AVHRR AMV R2	1982 – 2016	NOAA-7-19 (6, 8 and 10 missing), Metop A/B	Produced and under validation	Consolidation and archival expected 2018
TCDR surface albedo R1	1982 – 2010	Meteosat 2-7	Archived and accessible from Data Centre	Includes IODC, ADC and XADC data coverage.
TCDR surface albedo R2	1982 – 2010	Meteosat 2-7	Produced and under validation	MSG will be added in 2018.
TCDR AMV, CSR and ASR R1	2004 – 2012	Meteosat 8, 9	Archived and accessible from Data Centre	
TCDR AMV, CSR and ASR R2	1982 - 2014	Meteosat 2-9	Produced and under validation	Consolidation and archival expected 2018

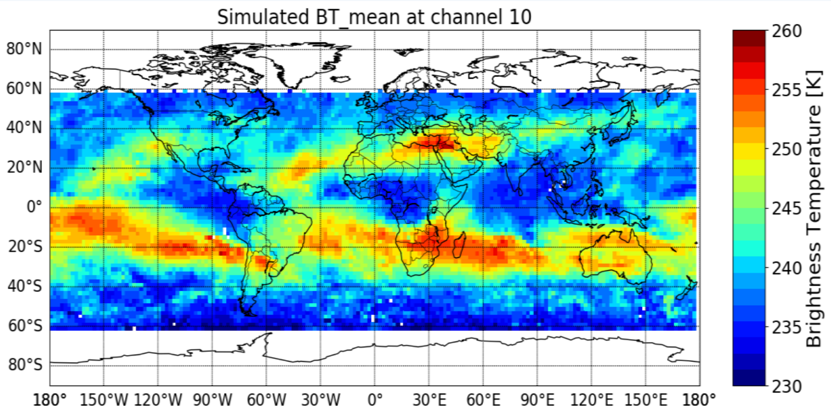
EUMETSAT

Analysis of NIMBUS-6 HIRS-1 Data

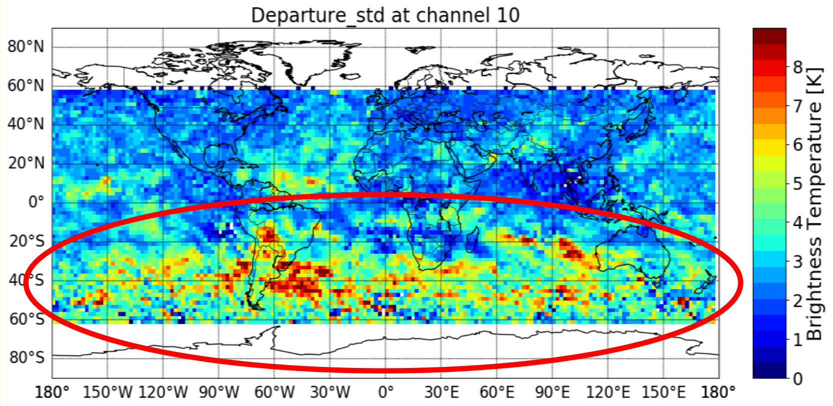
Climate Change



Nimbus-6 (Aug 1975)



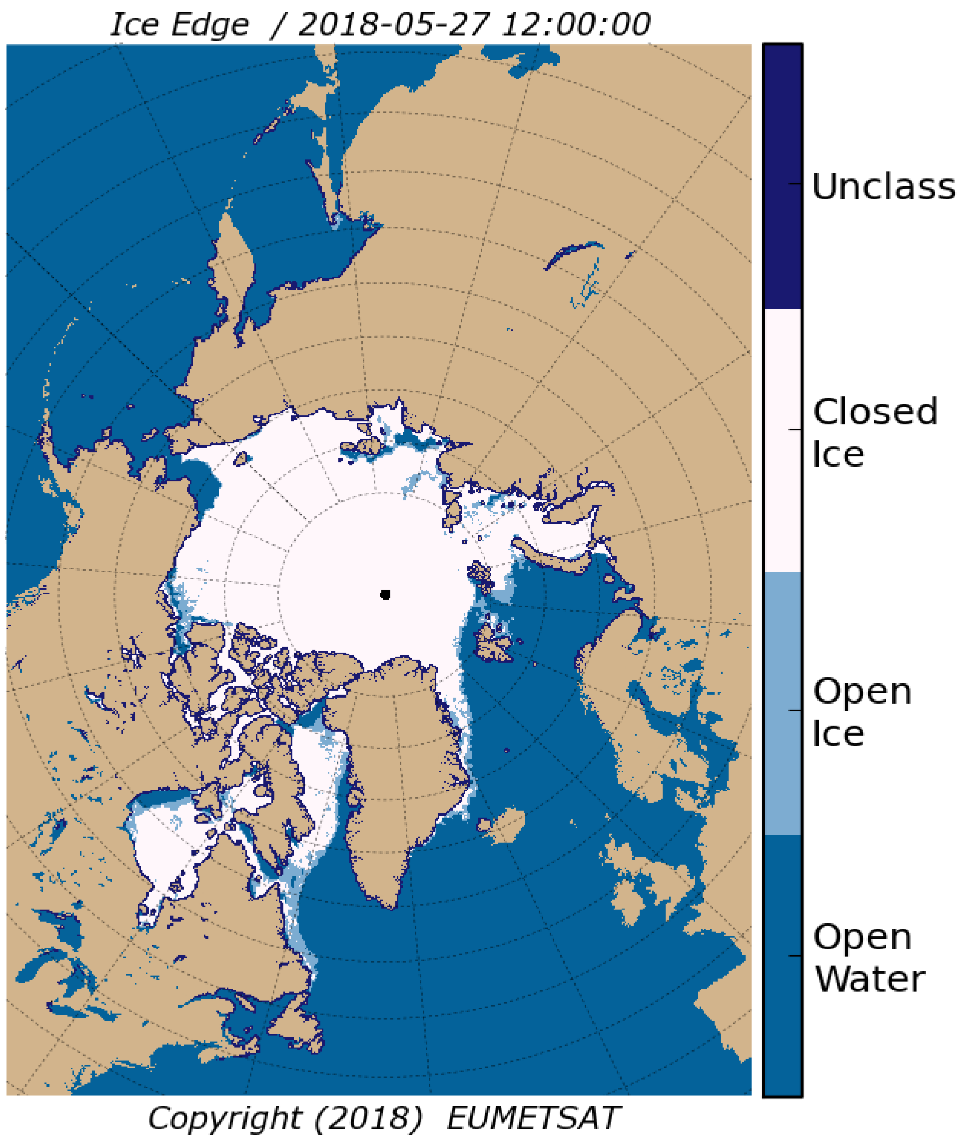
ERA-5 (Aug 1975)

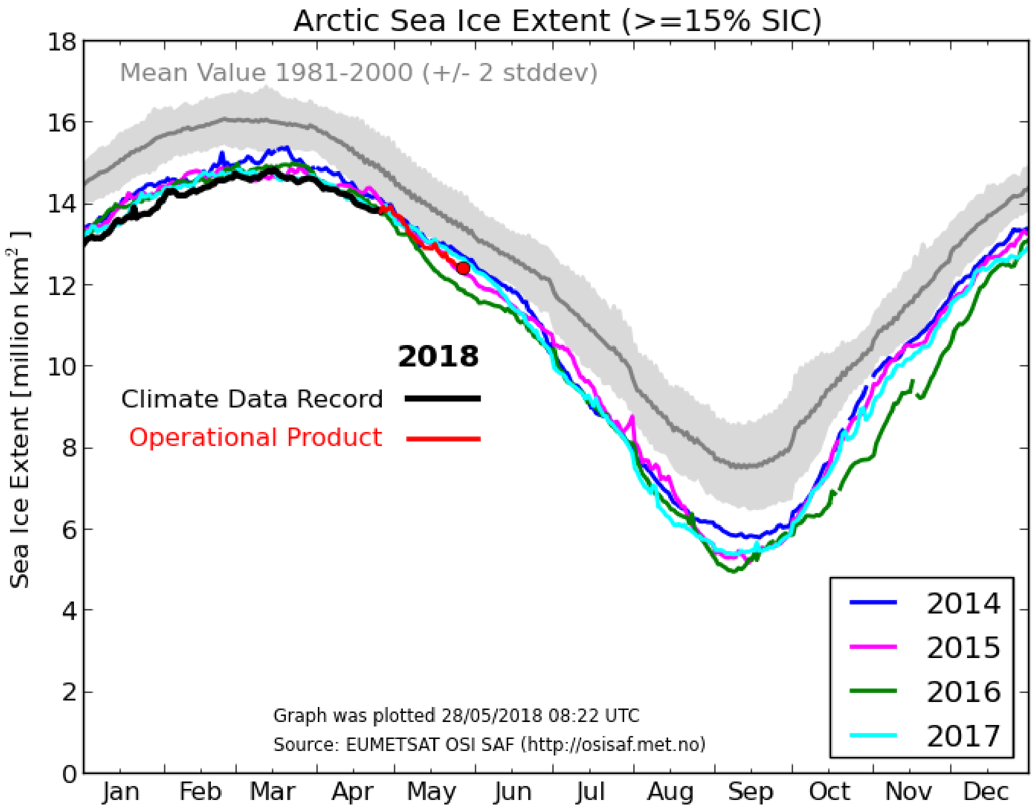


Standard Deviation
Nimbus-6 – ERA-5 departures

EUMETSAT ECMWF Copernicus Europe's eyes on Earth European Commission

Interim Climate Data Record: Climate in "real time"

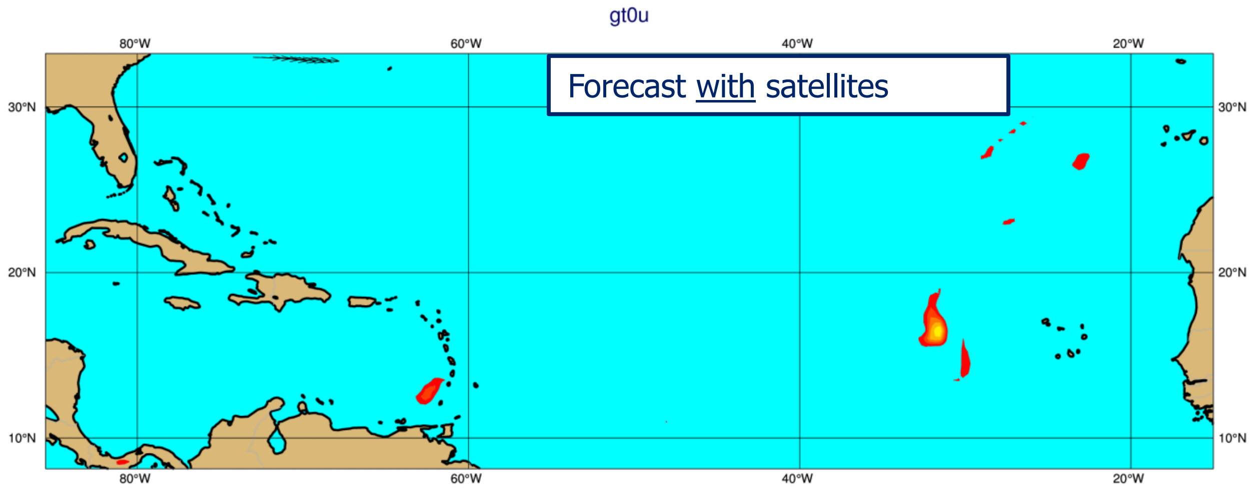




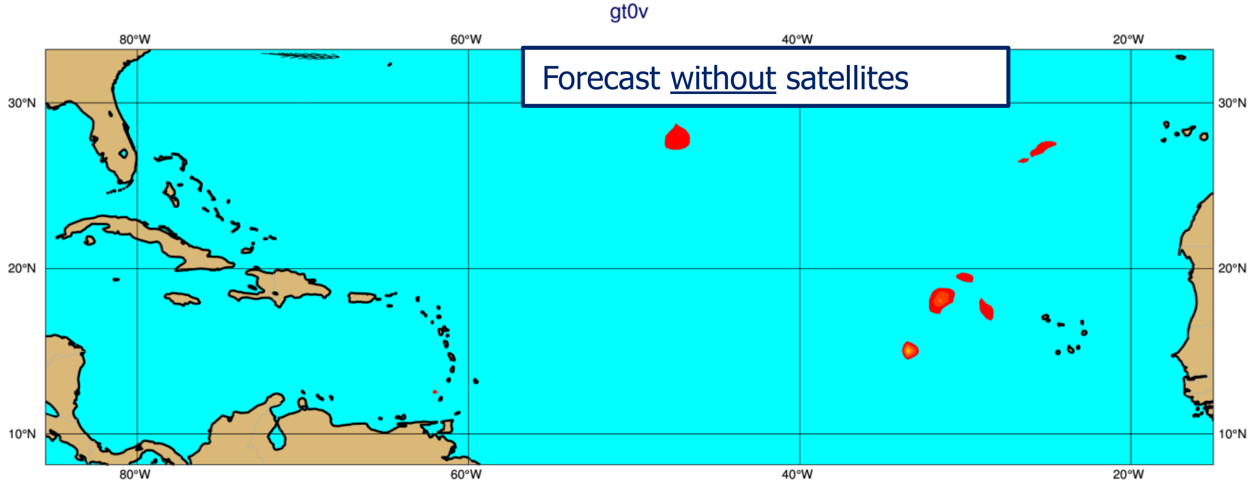
Daily updated Northern Hemisphere Sea Ice Extent compared to long term data record

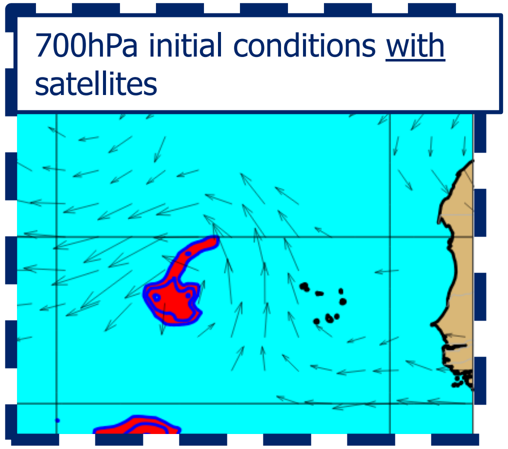
EUMETSAT

From Climate to Weather: Impacts and Preparedness

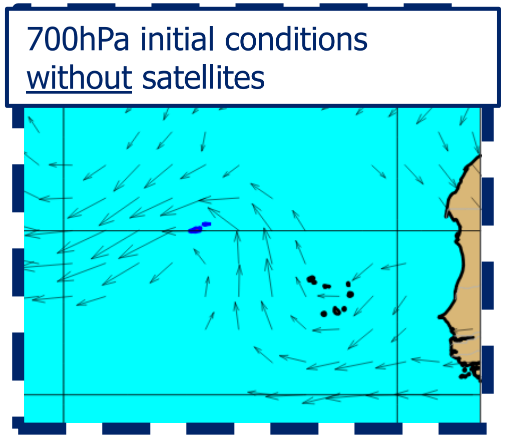


Thursday 31 August 2017 00 UTC ecmf 500 hPa Vorticity (relative)
Thursday 31 August 2017 00 UTC ecmf 500 hPa U component of wind/V component of wind





Red shading humidity > 95%



ECMWF

EUMETSAT

Summary Part II

- Satellites are essential for climate monitoring and science-based climate information services: 37 ECVs accessible;
- 40+ years of observations is a unique asset, data from operational satellite missions provide a big share of this;
- EUMETSAT is committed to continuity and improvement of observations for 20+ years, directly and through Copernicus;
- Data rescue is essential for satellite data to enable longest possible time series;
- Production of climate data records is a demanding scientific task:
  - Existing measurements need analysis and re-calibration per instrument once effects are understood;
  - Measurement series from same types of instruments can be harmonised leaving only expected differences, e.g., from SRF in the time series;
  - Analysis of measurements and harmonisation needs to establish uncertainty estimates which are crucial for use in data assimilation and retrieval.
- EUMETSAT supports forecasting of high impact weather attributable to climate change.